

# Using the Battery Management System

## Capabilities of the System

The Battery Management System (BMS) does the following:

- Monitors each battery in the system and optimizes the state of its charge.
- Identifies failing or failed batteries so that you can replace them before they cause damage to other batteries in the same string.
- Extends battery life and ensures that batteries are able to supply back-up power on demand.
- Integrates new replacement batteries with older existing batteries.

## Capacity

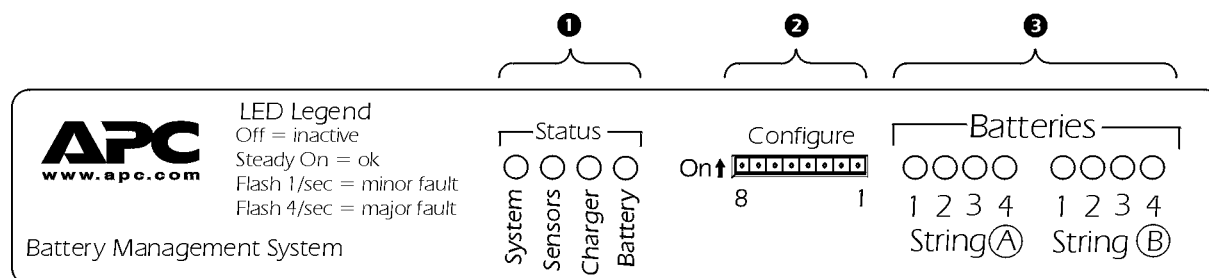
You can use a Battery Management System to manage one or two strings of two to four batteries each. The batteries must be six-cell batteries that have a nominal 12 VDC. The system can manage batteries that are manufactured by different vendors, and show different voltages during charging.

## Sensors

The Battery Management System monitors electrical current and ambient temperature through current and temperature sensors (probes).

- Each current probe measures the charge and discharge current of its battery string. The Battery Management System uses this measurement to assess the performance of individual batteries, and to determine when the batteries are discharging. APC Field Service personnel can use the information about the current of the battery string for diagnostic purposes.
- The ambient temperature probe measures the temperature of the air inside the battery cabinet.
- The system uses the ambient temperature and proprietary algorithms to derive the internal battery temperature.

## Front panel



|   |                            |
|---|----------------------------|
| ① | Status LEDs                |
| ② | Configuration DIP switches |
| ③ | Battery LEDs               |

# Adding or Removing Components

## Adding or Removing a Battery String

Disconnect power to the system



Warning

When adding or removing a battery string, first disconnect power to the Battery Management System by unplugging the power input cable to avoid causing sparks that could cause a battery to explode.

### Connect the new battery string



See also

See the installation guide (990-1224B), which came with your system, for battery string connection instructions. It is also available on the APC Web site ([www.apc.com](http://www.apc.com)).



Note

The Battery Management System auto-detects the new battery string. Verify that the polarities of the two strings match. If they do not, the Battery Management System will not be able to detect the second string.

## Set the DIP switches

After disconnecting the input power, reset the DIP switches to configure the change in your system.



**Note**

The DIP Switches must be set to one of the following valid configurations. If the DIP switches are set incorrectly, your Battery Management System may not operate properly.

| Condition                   | Switch Number |     |     |     |     |     |     |     |
|-----------------------------|---------------|-----|-----|-----|-----|-----|-----|-----|
|                             | 8             | 7   | 6   | 5   | 4   | 3   | 2   | 1   |
| Gel Batteries*              |               |     |     |     |     |     |     | Off |
| AGM Batteries               |               |     |     |     |     |     |     | On  |
| Four Batteries per string * |               |     |     |     |     | Off | Off |     |
| Three Batteries per string  |               |     |     |     |     | Off | On  |     |
| Two Batteries per string    |               |     |     |     |     | On  | Off |     |
| Ambient Temp Compensation*  |               |     |     |     | Off |     |     |     |
| Battery Temp Compensation   |               |     |     |     | On  |     |     |     |
| 25 Amp Hour Batteries *     | Off           | Off | Off | Off |     |     |     |     |
| 30 Amp Hour Batteries       | Off           | Off | Off | On  |     |     |     |     |
| 35 Amp Hour Batteries       | Off           | Off | On  | Off |     |     |     |     |
| 40 Amp Hour Batteries       | Off           | Off | On  | On  |     |     |     |     |
| 45 Amp Hour Batteries       | Off           | On  | Off | Off |     |     |     |     |
| 50 Amp Hour Batteries       | Off           | On  | Off | On  |     |     |     |     |
| 60 Amp Hour Batteries       | Off           | On  | On  | Off |     |     |     |     |
| 70 Amp Hour Batteries       | Off           | On  | On  | On  |     |     |     |     |
| *Default Setting            |               |     |     |     |     |     |     |     |

| Condition              | Switch Number |     |     |     |   |   |   |   |
|------------------------|---------------|-----|-----|-----|---|---|---|---|
|                        | 8             | 7   | 6   | 5   | 4 | 3 | 2 | 1 |
| 80 Amp Hour Batteries  | On            | Off | Off | Off |   |   |   |   |
| 90 Amp Hour Batteries  | On            | Off | Off | On  |   |   |   |   |
| 100 Amp Hour Batteries | On            | Off | On  | Off |   |   |   |   |
| 115 Amp Hour Batteries | On            | Off | On  | On  |   |   |   |   |
| 125 Amp Hour Batteries | On            | On  | Off | Off |   |   |   |   |
| 150 Amp Hour Batteries | On            | On  | Off | On  |   |   |   |   |
| 175 Amp Hour Batteries | On            | On  | On  | Off |   |   |   |   |
| 200 Amp Hour Batteries | On            | On  | On  | On  |   |   |   |   |
| *Default Setting       |               |     |     |     |   |   |   |   |

## Install a current sensor

If you add a second battery string to a system that had only one string, you need to install a second current sensor. The system needs one sensor per string to measure the current throughout the string.

1. Set the DIP switches on the new current sensor to identify its location correctly.
2. Plug the ambient temperature sensor into the unused port on the current sensor to be located at the warmest area of the enclosure. Connect the two current sensors to each other with the supplied cable.
3. Use the remaining cable to connect the sensor string to the sensor port at the back of the Battery Management System. Unless at least one current sensor is connected to the sensor port, neither current sensor will be able to report information. If a current or temperature sensor is not functioning, always check this connection first.
4. Calibrate the new current sensor.



See also

See the *Installation and Quick-Start Manual* for detailed instructions on calibrating the current sensors.

5. Install the current sensor in the new string, ensuring that the current sensor is oriented correctly with a load carrying conductor passing through it.



See also

For detailed instructions on how to install temperature and current sensors and to set the DIP switches correctly, see the *Installation and Quick-Start Manual*.

## Restart the Battery Management System

After adding or removing a battery string, restart the Battery Management System by reconnecting the power input cable that you disconnected. At start-up, the Battery Management System integrates any new battery string and resets each battery's "current acceptance" (response) benchmark.



Note

After the system restarts, check the **Batteries** LEDs. If the LED for each battery in the system is illuminated, you connected the batteries and set the battery DIP switches correctly. Once the start-up LED check is complete and battery string discovery is complete, if any configured battery's LED turns off, recheck the connections and fuses for the associated battery. Refer to the [Troubleshooting](#) section for additional help.

# Troubleshooting

## LED Definitions

The twelve LEDs on the front panel of the Battery Management System indicate the status of the system. The Battery Management System does not require a computer. The system notifies you of battery conditions and any system alarms through a set of LEDs and alarm relays. See [LED states](#), and [Interpreting alarms](#).

As a test, all LEDs turn on for 3 seconds when the system starts up.



**Note**

Observe this test carefully at start-up. An LED could be off because it has failed rather than for the reasons cited in the following table.

### LED states

The state of each LED indicates the following:

| LED Action               | Meaning                                                                                         |
|--------------------------|-------------------------------------------------------------------------------------------------|
| On                       | Function is active and normal                                                                   |
| Flashing 1/second (Slow) | Function has a Minor Fault                                                                      |
| Flashing 4/second (Fast) | Function has a Major fault                                                                      |
| Off                      | Function is inactive due to either failure to detect it or to indicate non-configured batteries |

## Alarm indicators

Refer to the following table to determine the status of your system and follow the link for each event for more information.

| Event                                                                                                        | Status LEDs |        |              |         | Alarm Relays |        | Battery LEDs                   |
|--------------------------------------------------------------------------------------------------------------|-------------|--------|--------------|---------|--------------|--------|--------------------------------|
|                                                                                                              | System      | Sensor | Charger      | Battery | Major        | Minor  |                                |
| Normal Operation                                                                                             | On          | On     | On           | On      | Open         | Open   | Active batteries on            |
| Sensor calibration                                                                                           | Slow        | Slow   | Slow         | Slow    | Open         | Open   | Affected Strings Flashing Slow |
| Loss of System Power                                                                                         | Off         | Off    | Off          | Off     | Open         | Open   | All Off                        |
| Sensor Input Fault                                                                                           | Slow        | Off    | Off          | Off     | Open         | Closed | All Off                        |
| String Polarity Mismatch                                                                                     | On          | On     | On           | On      | Open         | Open   | All String B Off               |
| Battery String A Missing                                                                                     | Slow        | On     | Off          | Off     | Open         | Closed | All Off                        |
| Blown Fuse or Open Circuit on Battery String Connector                                                       | Slow        | On     | On/<br>Slow† | On      | N/A          | Closed | Affected batteries Off         |
| Discharge or Charger Inactive                                                                                | On          | On     | Off          | On      | N/A          | Closed | N/A                            |
| Charger Voltage Low                                                                                          | On          | On     | Slow         | On      | N/A          | Closed | N/A                            |
| Charger Voltage High                                                                                         | On          | On     | Fast         | On      | Closed       | N/A    | N/A                            |
| Minor Battery Fault                                                                                          | On          | On     | N/A          | Slow    | N/A          | Closed | Affected battery flashing slow |
| Major Battery Fault                                                                                          | On          | On     | N/A          | Fast    | Closed       | N/A    | Affected battery flashing fast |
| N/A — LED or Relay not affected, see other criteria for indications                                          |             |        |              |         |              |        |                                |
| † A blown fuse or other open circuit in the battery string connectors may cause a Charger Voltage Low alarm. |             |        |              |         |              |        |                                |

## Interpreting alarms

The Battery Management System can generate Major or Minor alarms.

- A *Major alarm* requires **immediate** action to ensure that the batteries are able to provide back-up power.
- A *Minor alarm* indicates a condition that is not likely to result in the batteries being unable to provide back-up power, but could develop into a major alarm, or could prevent the detection of a major alarm.

Each alarm type will close an associated normally-open alarm relay. The alarm relays can be connected to a device that monitors normally-open and normally-closed sensors.

**Sensor calibration.** The Battery Management System is in sensor calibration mode. You can set this mode by setting DIP switch 4 (on each sensor) to **On**. The Battery Management System will then obtain a new zero value. The LEDs will flash at a rate of once per second while the Battery Management System is in this mode. After five flashes, the sensor is calibrated.



**Caution**

Do not perform sensor calibration while there is current flowing through the sensor. Remove the sensor from the battery cable before performing a sensor calibration.

| Possible Causes                                              | Corrective Action                                                                                                  |
|--------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------|
| The Battery Management System is in sensor calibration mode. | <ul style="list-style-type: none"> <li>• Set the current sensor's DIP switch number four to <b>Off</b>.</li> </ul> |



**See also**

See the *Installation and Quick-Start Manual* for instructions on how to calibrate the sensors.

**Loss of System Power.** The Battery Management System is not powered.

| Possible Causes                                 | Corrective Action                                                                                                                                                                                                                                                                             |
|-------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Power leads are swapped or backwards            | <ul style="list-style-type: none"><li>• Reverse the power leads.</li></ul>                                                                                                                                                                                                                    |
| Power leads are not connected to a power source | <ul style="list-style-type: none"><li>• Connect the Battery Management System to a power source.</li></ul>                                                                                                                                                                                    |
| Blown power lead fuse                           | <ul style="list-style-type: none"><li>• Check the Battery wire harness for pinched or frayed wires.</li><li>• Replace the fuse. Monitor the Battery Management System for more blown power lead fuses, as this is a sign of an internal problem with the Battery Management System.</li></ul> |

**Sensor Input Fault.** Minor Alarm. The number of sensors the BMS detects does not match the number of battery strings.

| Possible Causes                                         | Corrective Action                                                                                                                                                                                                                                                                    |
|---------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Current sensor is not installed on each battery string. | <ul style="list-style-type: none"><li>• Install a current sensor for each battery string connected to the Battery Management System.</li></ul>                                                                                                                                       |
| Current sensors not correctly addressed.                | <ul style="list-style-type: none"><li>• Check DIP switch settings for each current sensor. String A's sensor should have DIP switch #1 set to <b>On</b> (all others <b>Off</b>), and String B's sensor should have DIP switch #2 set to <b>On</b> (all others <b>Off</b>).</li></ul> |
| Ambient temperature sensor missing                      | <ul style="list-style-type: none"><li>• Install an ambient temperature sensor in the open port on one of the current sensors.</li></ul>                                                                                                                                              |

**String Polarity Mismatch.** The second battery string's polarity is reversed from the polarity of the first battery string. The Battery Management System will not detect the second string if its polarity is reversed.

| Possible Causes                                                             | Corrective Action                                                                                                                 |
|-----------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------|
| Second battery string's polarity does not match the first string's polarity | <ul style="list-style-type: none"> <li>Reverse the order of the battery leads connected to one of the battery strings.</li> </ul> |

**Battery String A Missing.** Minor Alarm. At start-up, the Battery Management System twice attempts to detect the polarity of Battery String A. If both attempts fail, the Battery Management System generates a **Battery String A missing** fault.

| Possible Causes                                          | Corrective Action                                                                                                                                                                             |
|----------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Single battery string is connected to the String B input | <ul style="list-style-type: none"> <li>Connect the battery string to the String A connector. If you are using only one battery string, it must be connected to the String A input.</li> </ul> |
| Blown battery lead fuse on String A, Battery #1          | <ul style="list-style-type: none"> <li>Replace the blown battery lead fuse.</li> </ul>                                                                                                        |

**Blown Fuse or Open Circuit on Battery String Connector.** Minor Alarm. The BMS detects an individual battery voltage of less than 3 VDC.

| Possible Cause                             | Corrective Action                                                                               |
|--------------------------------------------|-------------------------------------------------------------------------------------------------|
| Blown battery lead fuse                    | <ul style="list-style-type: none"> <li>Replace the blown battery lead fuse.</li> </ul>          |
| Open circuit in the battery wiring harness | <ul style="list-style-type: none"> <li>Check the battery wiring harness connections.</li> </ul> |

**Discharge or Charger Inactive.** Minor Alarm. The BMS detects 5 amps of continuous discharge current on either battery string for more than 5 seconds.

| Possible Causes                                                 | Corrective Action                                                                                                                                                                        |
|-----------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Loss of AC to power supply                                      | <ul style="list-style-type: none"> <li>• Restore AC input before batteries are exhausted.</li> </ul>                                                                                     |
| Power supply overloaded                                         | <ul style="list-style-type: none"> <li>• Check for short circuits on load</li> <li>• Remove excess load on system</li> </ul>                                                             |
| Current sensor entered calibration mode during a battery charge | <ul style="list-style-type: none"> <li>• Re-calibrate current sensor(s) by performing calibration with no current flowing.</li> </ul>                                                    |
| Current sensor installation reversed                            | <ul style="list-style-type: none"> <li>• If a discharge is indicated while the batteries are charging, reverify orientation of sensor and reverse if not installed correctly.</li> </ul> |

**Charger Voltage Low.** Minor Alarm. After a discharge or application of power, the Charger Voltage Low alarm condition is ignored for 60 minutes. After the 60-minute delay, the Charger Voltage Low alarm occurs if the string voltage value (the sum of all battery voltages in the string) is below the string voltage limits.

| Possible Causes                                                                             | Corrective Action                                                                                                                                                                   |
|---------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Power supply charger setting too low or failure of charger temperature compensating circuit | <ul style="list-style-type: none"> <li>• Check charging system.</li> <li>• Reset charger voltage or repair if required.</li> </ul>                                                  |
| Incorrect temperature compensation selected                                                 | <ul style="list-style-type: none"> <li>• Verify that the configured temperature compensation method (ambient or battery) matches the power supply's compensation method.</li> </ul> |

**Charger Voltage High.** Major Alarm. After a discharge or application of power, the Charger Voltage High alarm condition is ignored for 60 minutes. After the 60-minute delay, the Charger Voltage High alarm occurs if the string voltage value (the sum of all battery voltages in the string) is above the string voltage limits.

| Possible Causes                                                                              | Corrective Action                                                                                                                                                                   |
|----------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Power supply charger setting too high or failure of charger temperature compensating circuit | <ul style="list-style-type: none"> <li>• Check charging system.</li> <li>• Reset charger voltage or repair if required.</li> </ul>                                                  |
| Incorrect temperature compensation selected                                                  | <ul style="list-style-type: none"> <li>• Verify that the configured temperature compensation method (ambient or battery) matches the power supply's compensation method.</li> </ul> |

**Minor Battery Fault.** Minor battery alarms are unfavorable conditions that usually do not result in the loss of the critical load but could develop into a major alarm or would prevent the detection of a major alarm condition.

| Possible Causes                             | Corrective Action                                                                                 |
|---------------------------------------------|---------------------------------------------------------------------------------------------------|
| Blown fuse                                  | <ul style="list-style-type: none"> <li>• Replace the blown battery lead fuse.</li> </ul>          |
| Open circuit in the battery wiring harness  | <ul style="list-style-type: none"> <li>• Check the battery wiring harness connections.</li> </ul> |
| Short circuit in the battery wiring harness | <ul style="list-style-type: none"> <li>• Check the battery wiring harness connections.</li> </ul> |

**Major Battery Fault.** Major battery alarms require immediate corrective action. They usually result in the loss of the critical load during emergency battery operation.

| Possible Causes        | Corrective Action          |
|------------------------|----------------------------|
| Shorted cell           | • Replace affected battery |
| Thermal runaway        | • Replace affected battery |
| Dryout/suflation/opens | • Replace affected battery |
| Very low capacity      | • Replace affected battery |

# Product Information

## Specifications

### Electrical

| Item                    | Specification |
|-------------------------|---------------|
| Operating voltage range | 22 – 54 VDC   |
| Monitoring current      | 1.6 A         |
| Maximum (Boost) current | 3.5 A         |
| Monitoring power        | 37 W          |
| Maximum (Boost) power   | 75 W          |

## Physical

| Item                            | Specification                                  |
|---------------------------------|------------------------------------------------|
| Dimensions (H × W × D)          | 1.75 × 10 × 4 in (4.45 × 25.4 × 10.16 cm)      |
| Net weight                      | 2.2 lb (1.0 kg)                                |
| Shipping dimensions (H × W × D) | 5.3 × 11.5 × 8.3 in (13.46 × 29.21 × 21.08 cm) |
| Shipping weight                 | 6 lb (2.7 kg)                                  |

## Environmental

| Item                                                                                                   | Specification                                                    |
|--------------------------------------------------------------------------------------------------------|------------------------------------------------------------------|
| Elevation (above MSL) <ul style="list-style-type: none"> <li>• Operating</li> <li>• Storage</li> </ul> | 10,000 ft (3000 m)<br>50,000 ft (15 000 m)                       |
| Temperature <ul style="list-style-type: none"> <li>• Operating</li> <li>• Storage</li> </ul>           | – 40 to 140° F (– 40 to 60° C)<br>– 40 to 149° F (– 40 to 65° C) |
| Relative humidity: operating and storage                                                               | 5 – 95% RH non-condensing.                                       |

## Approvals/Standards

|           |                                                           |
|-----------|-----------------------------------------------------------|
| Approvals | CE, EN55024, FCC part 15, ICES-003, CISPR22, VCCI, C-Tick |
|-----------|-----------------------------------------------------------|

# Warranty and Service

## Limited warranty

APC warrants the Battery Management System to be free from defects in materials and workmanship for a period of two years from the date of purchase. Its obligation under this warranty is limited to repairing or replacing, at its own sole option, any such defective products. This warranty does not apply to equipment that has been damaged by accident, negligence, or misapplication or has been altered or modified in any way. This warranty applies only to the original purchaser.

## Warranty limitations

**Except as provided herein, APC makes no warranties, express or implied, including warranties of merchantability and fitness for a particular purpose.** Some jurisdictions do not permit limitation or exclusion of implied warranties; therefore, the aforesaid limitation(s) or exclusion(s) may not apply to the purchaser.

**Except as provided above, in no event will APC be liable for direct, indirect, special, incidental, or consequential damages arising out of the use of this product, even if advised of the possibility of such damage.**

Specifically, APC is not liable for any costs, such as lost profits or revenue, loss of equipment, loss of use of equipment, loss of software, loss of data, costs of substitutes, claims by third parties, or otherwise. This warranty gives you specific legal rights and you may also have other rights, which vary according to jurisdiction.

## Obtaining service

To obtain support for problems with your Battery Management System:

1. Note the serial number and date of purchase. The serial number is on the bottom of the unit.
2. Contact Customer Support at a phone number at the end of this user's guide. A technician will try to help you solve the problem by phone.
3. If you must return the product, the technician will give you a return material authorization (RMA) number. If the warranty expired, you will be charged for repair or replacement.
4. Pack the unit carefully. The warranty does not cover damage sustained in transit. Enclose a letter with your name, address, RMA number and daytime phone number; a copy of the sales receipt; and a check as payment, if applicable.
5. Mark the RMA number clearly on the outside of the shipping carton.
6. Ship by insured, prepaid carrier to the address provided by the Customer Support technician.

# Life-Support Policy

## General policy

American Power Conversion (APC) does not recommend the use of any of its products in the following situations:

- In life-support applications where failure or malfunction of the APC product can be reasonably expected to cause failure of the life-support device or to affect significantly its safety or effectiveness.
- In direct patient care.

APC will not knowingly sell its products for use in such applications unless it receives in writing assurances satisfactory to APC that (a) the risks of injury or damage have been minimized, (b) the customer assumes all such risks, and (c) the liability of American Power Conversion is adequately protected under the circumstances.

## Examples of life-support devices

The term *life-support device* includes but is not limited to neonatal oxygen analyzers, nerve stimulators (whether used for anesthesia, pain relief, or other purposes), autotransfusion devices, blood pumps, defibrillators, arrhythmia detectors and alarms, pacemakers, hemodialysis systems, peritoneal dialysis systems, neonatal ventilator incubators, ventilators (for adults and infants), anesthesia ventilators, infusion pumps, and any other devices designated as “critical” by the U.S. FDA.

Hospital-grade wiring devices and leakage current protection may be ordered as options on many APC UPS systems. APC does not claim that units with these modifications are certified or listed as hospital-grade by APC or any other organization. Therefore these units do not meet the requirements for use in direct patient care.

## APC Worldwide Customer Support

Customer support for this or any other APC product is available at no charge in any of the following ways:

- Visit the APC Web site to find answers to frequently asked questions (FAQS), to access documents in the APC Knowledge Base, and to submit customer support requests.
  - **www.apc.com** (Corporate Headquarters)  
Connect to localized APC Web sites for specific countries, each of which provides customer support information.
  - **www.apc.com/support/**  
Global support with FAQs, knowledge base, and e-support.
- Contact an APC Customer Support center by telephone or e-mail.
  - Regional centers:

|                               |                              |
|-------------------------------|------------------------------|
| APC headquarters U.S., Canada | (1)(800)800-4272 (toll free) |
| Latin America                 | (1)(401)789-5735 (USA)       |
| Europe, Middle East, Africa   | (353)(91)702020 (Ireland)    |
| Japan                         | (0) 35434-2021               |

- Local, country-specific centers: go to **www.apc.com/support/contact** for contact information.

Contact the APC representative or other distributor from whom you purchased your APC product for information on how to obtain local customer support.

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